Inter-comparison of MISR/MODIS CTHs and validation using Chilbolton and ARM SGP Radar+Lidar within the EU-CLOUDMAP2 Project

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In collaboration with Eugene Clothiaux (PennState University)

MODIS & MISR Science Team Member (NASA EOS Project)

POLDER (ADEOSI/II), VEGETATION (SPOT4), GLI (ADEOSII)
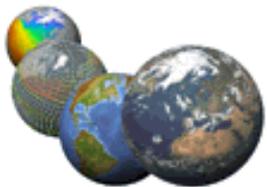
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Overview

- Context

- Objectives

- Inter-comparison of MISR-2TC with MOD06 CTHs

- Comparison of Cloud-Top Heights vs radar

- Future plans for MISR vs MODIS cloud studies at UCL

Context

- MISR stereo-derived Cloud-Top Height (CTH) product developed by Jan-Peter Muller and Roger Davies (UoA/JPL)

- first operational use of automated stereo matching and digital photogrammetry on any spaceborne platform

- Produces global CTH for all cloudy pixels on the day side

- EU-CLOUDMAP2 project (10 partners from 7 countries) developing system for production of cloud climatology for Europe (1995-2003), near real-time production of MODIS cloud products for MetOs and their NRT validation using ground-based radars and radiosonde

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Objectives

- Understand what biases and artefacts exist in the MISR CTH and MODIS CTP through inter-comparison and assessment of differences in terms of MODIS cloud microphysical parameters

- validate CTHs and understand differences between MISR and MODIS using ground-based mm-radar + lidar (in conjunction with Eugene Clothiaux, PSU)

MISR intercomparison with MODIS (1)

- MISR 2TC Stereo CTH product (above ellipsoid) includes correction of wind advection effects

- MOD06 CO2 CTP product transformed into geopotential CTH using ECMWF objective analyses *(all pixels where CTP retrieved with IR channel removed)*

- Extremely tedious to find MODIS products which correspond to MISR products
  - MOD06 uses different naming conventions(Julian day based, no orbit/Path #)
  - there is no EDG tool to find all tuples which overlap in time and/or space from instruments on the same platform!
  - MISR uses start time and MODIS uses actual time for start of each data granule which do not agree!!
  - MISR data granule is complete swath and currently does not include time-tags (being worked)

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MISR intercomparison with MODIS (2)

- MOD06 CTP at 5km, MISR 2TC at 1.1km
- Resampling of MISR 1.1km to 5km using weighted average which from previous tests gave best results
- Pixel-by pixel differences used to calculate statistics
- Residual error due to resampling not assessed
- Over British Isles: 23 cases have been studied. 7 are from 25/8/00 until 26/11/00, then from 05/03/01 to 11/07/01 all using the latest MISR processing chain

MISR intercomparison with MODIS : CTHs
Path 206/Orbit 3657(25-Aug-00):only high cloud case
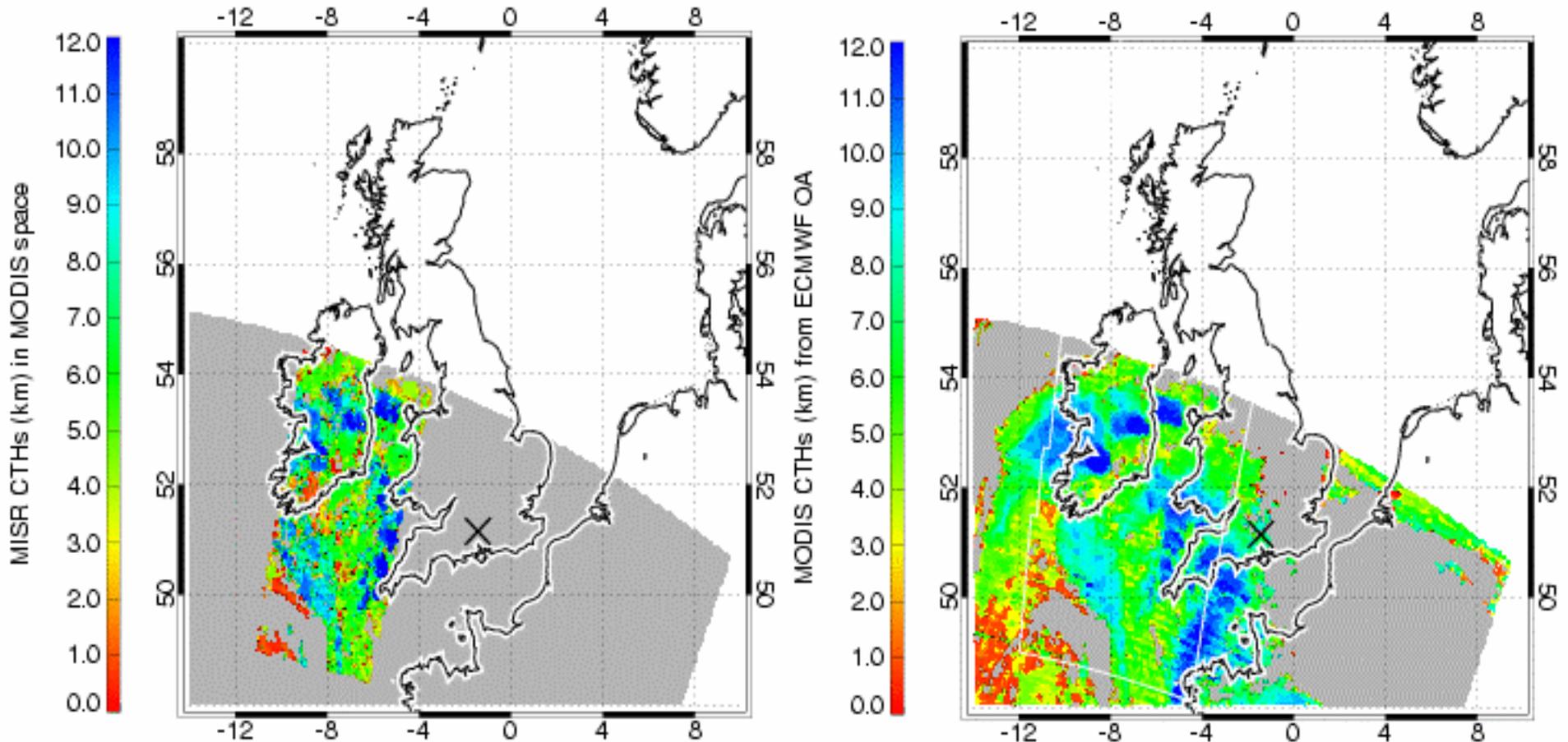
N.B. Missing data or clear-sky shown in grey. MISR has block artefact due to wind correction and MODIS has striping artefact due to poor performance of several MODIS channels

MISR intercomparison with MODIS and iCTH Path 206/Orbit 3657 (25-Aug-00):
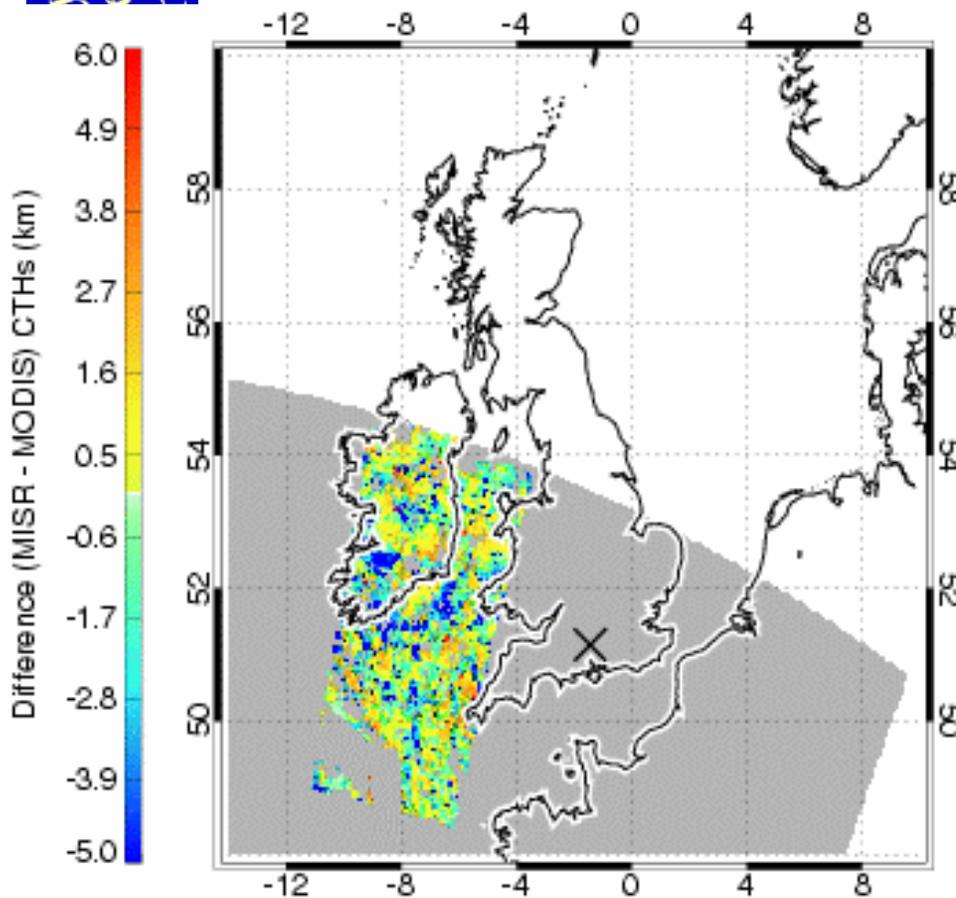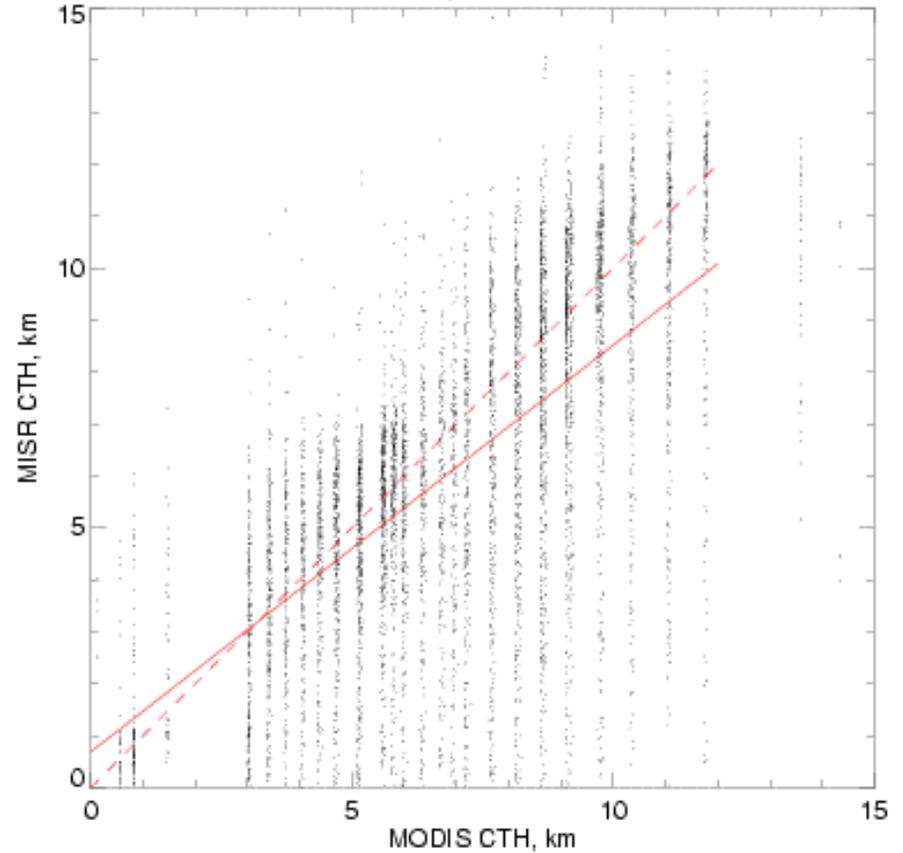
N.B. MISR CTHs higher than MODIS when MISR-CTH ≥ ≈5km
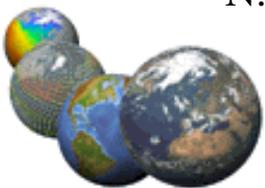
MISR-MODIS CTH cf. Optical depth cf. 1.38µm (red) Path 206/Orbit 3657 (25-Aug-00):
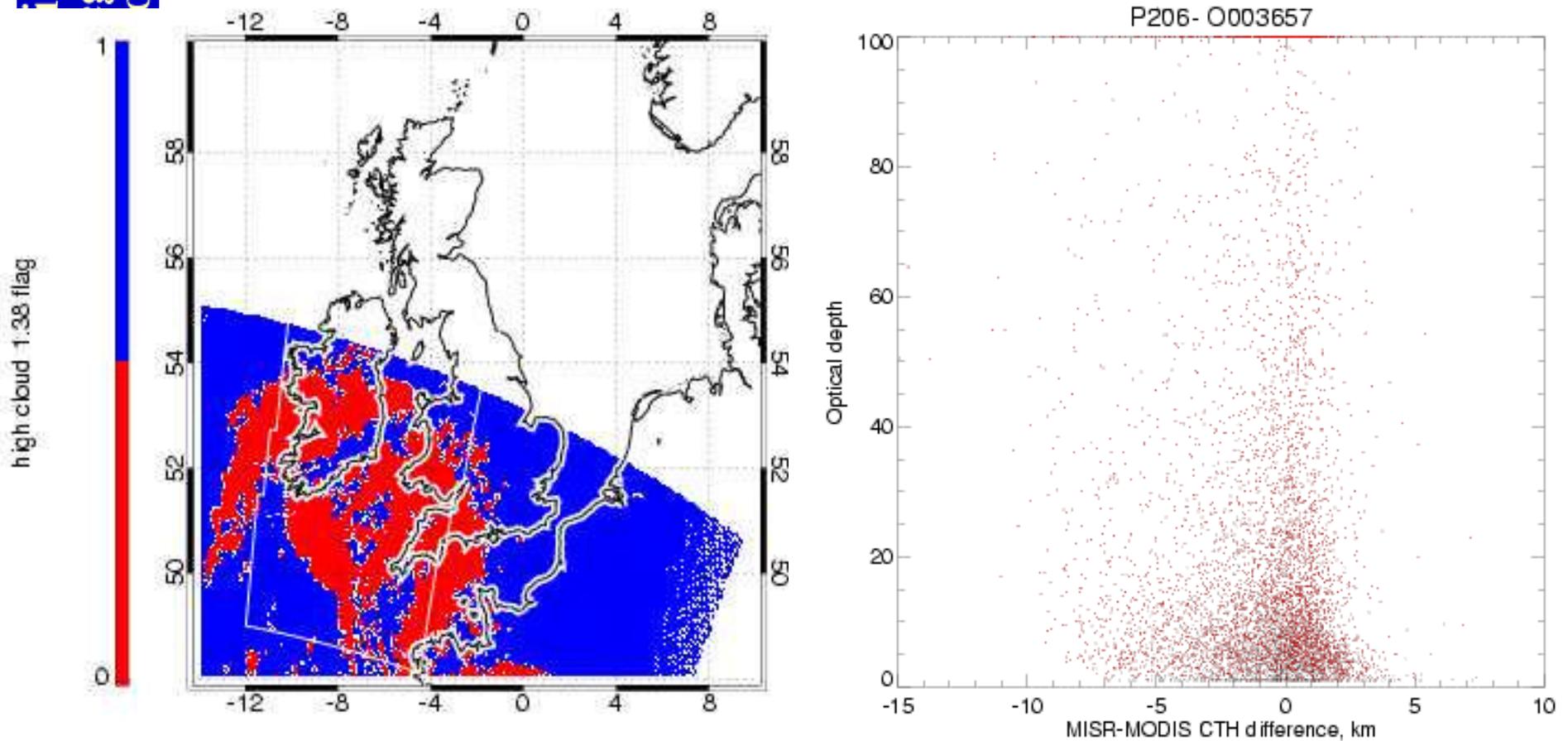
N.B. MISR CTHs higher than MODIS due to MISR detecting more thin high clouds

MISR vs MODIS CTH cf. MODIS CTH (red=1.38µm) Path 206/Orbit 3657 (25-Aug-00):
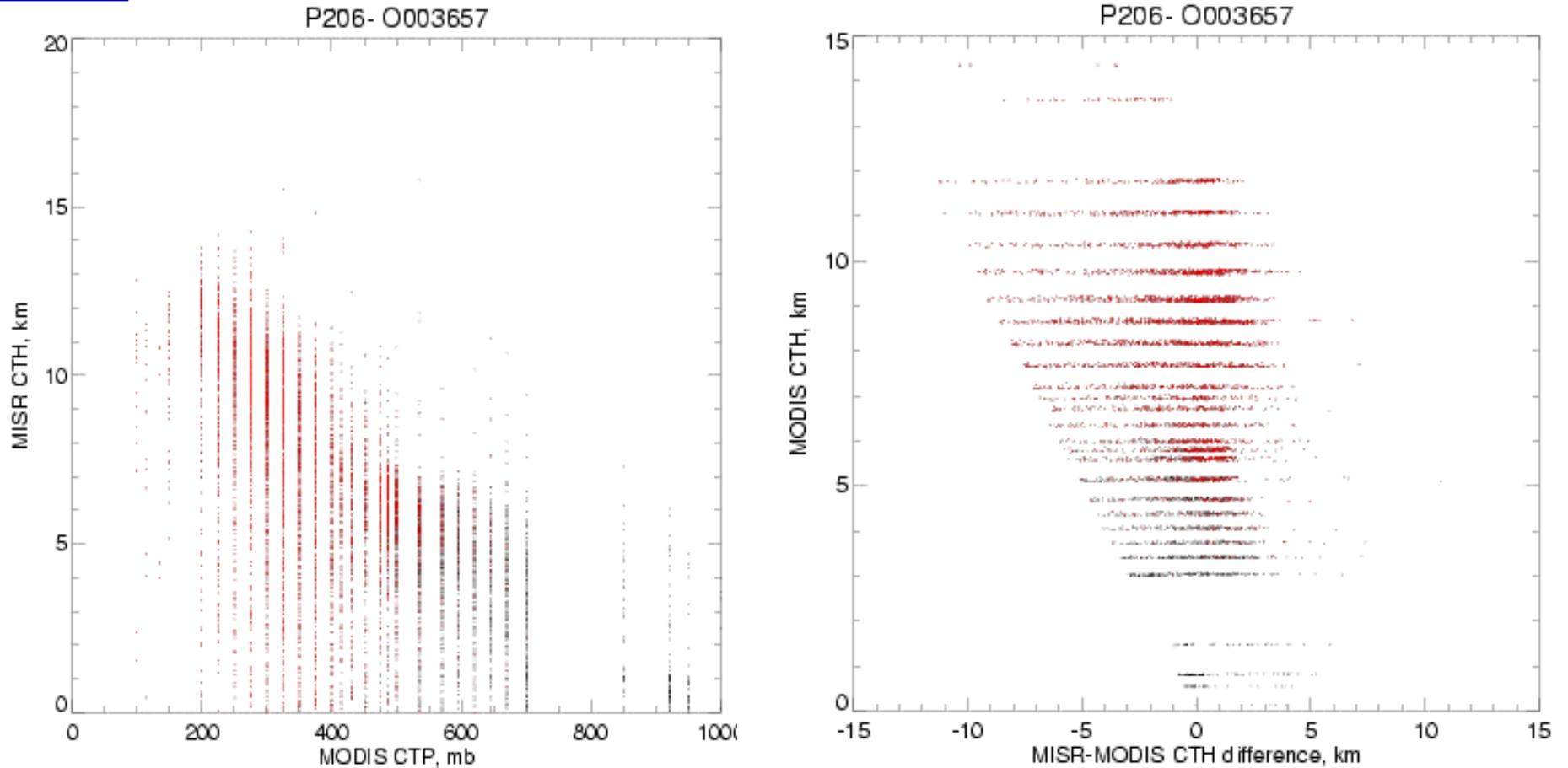
N.B. MODIS CTHs in layers due to NCEP fields on standard pressure levels and not due to use of ECMWF to convert MODIS CTPs to CTHs

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MISR vs MODIS CTH for British Isles: 23 cases (1)
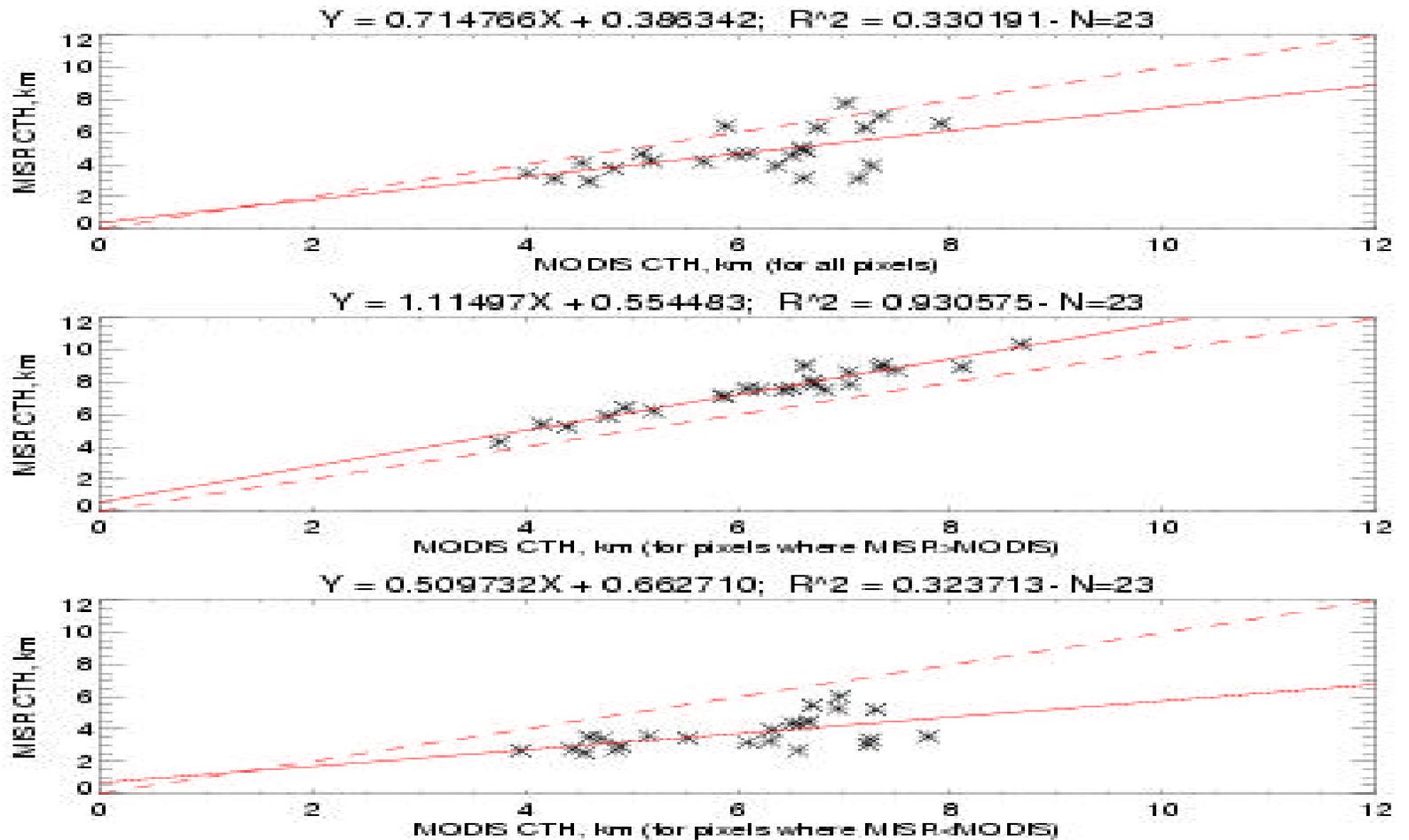
Average CTH for each date: MISR> MODIS mainly for high clouds

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MISR vs MODIS CTH over British Isles: 23 cases (2)
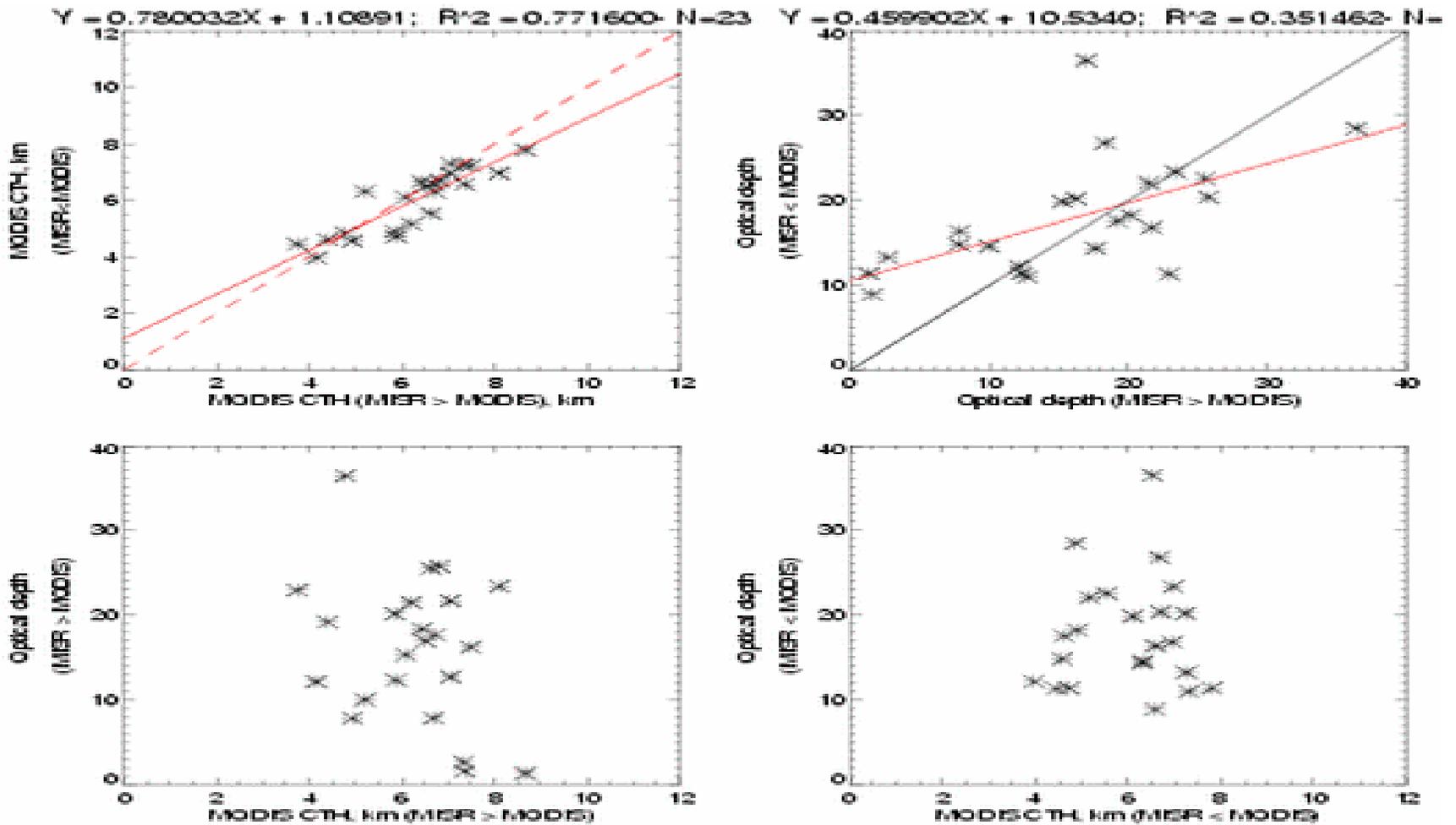
Where MISR > MODIS, MODIS CTHs are higher than for pixels where MISR<MODIS– but wide range of optical depths and no correlation with CTHs

Average MISR CTH > MODIS CTH: 25-Aug-00 and 22-Apr-01
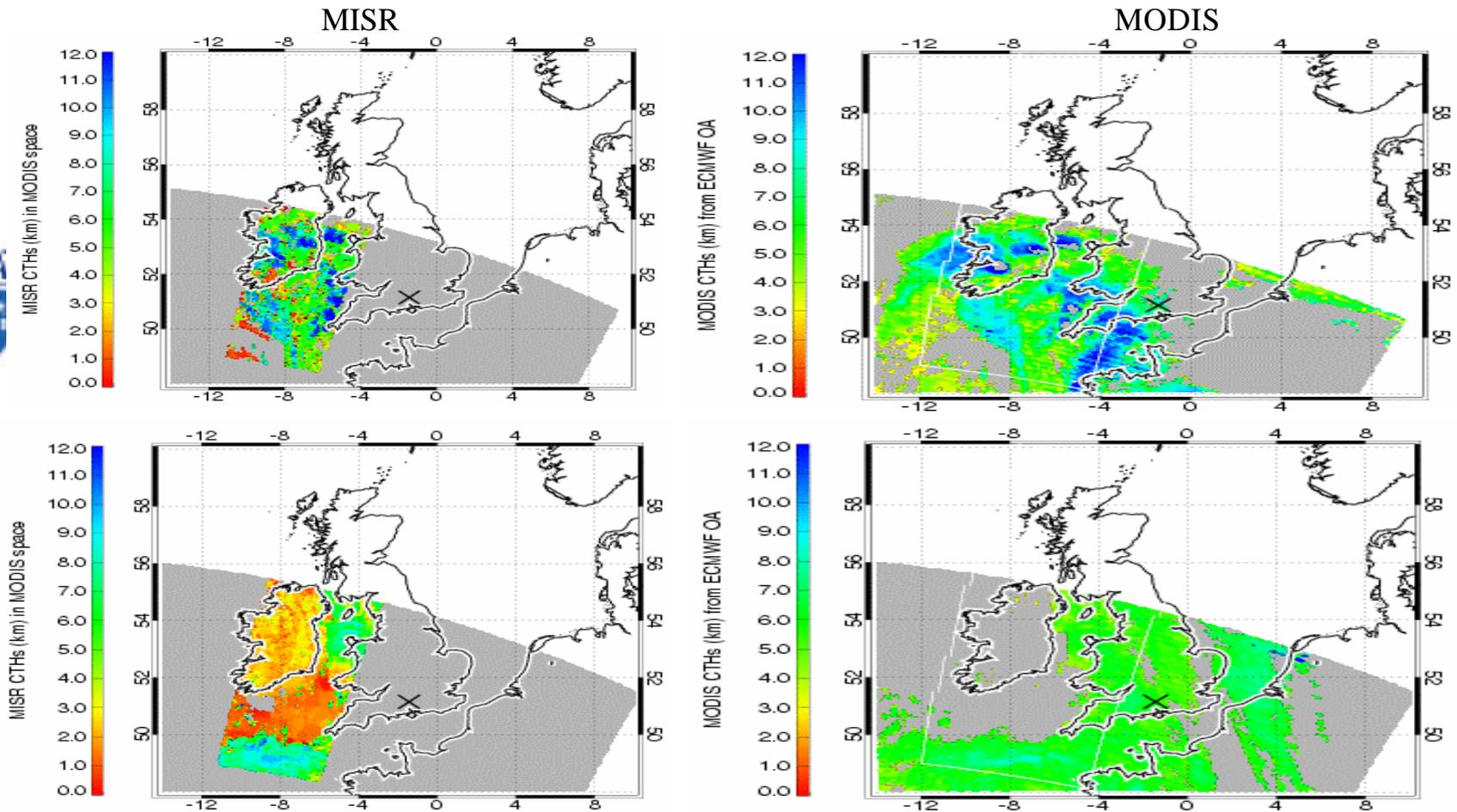
Top panel: 25-Aug-00 (P206-O3657) - lower panel: 22-Apr-01 (P206-O7152) NB : missing data for MODIS for CTH < 3km (based on IR-Bt retrieval only)

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Average MISR CTH < MODIS CTH: 30-Mar-01 and 13-Apr-01
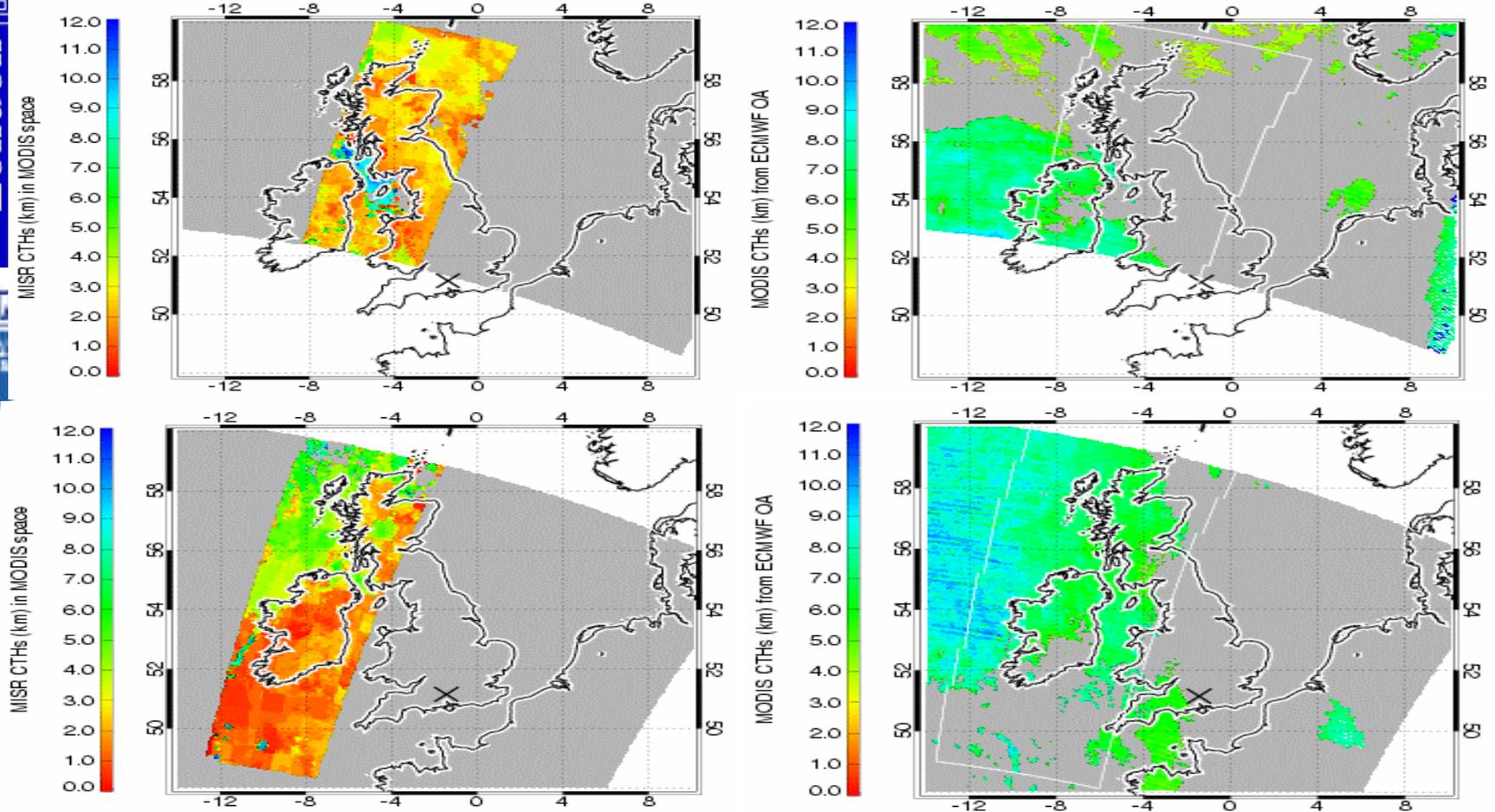
Top panel: 30-Mar-01 (P205-O6817) ; lower panel: 13-Apr-01 (P207-O7021).

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Comparison of MISR 2TC stereo and MODIS CTHs vs radar (1)

- 2 sites: Chilbolton (UK) and SGP ARM site (US)
- A small window of ±0.05° centred on Chilbolton and SGP was used to calculate the MISR and MODIS CTH statistics.
- 5min sampling of radar profiles, median CTH calculated for SGP from reflectivity clutter flag processed by E. Clothiaux
- CTH for Chilbolton had to be retrieved visually from maximum CTH in reflectivity plots
- Chilbolton: 3 dates only for MODIS, MISR and radar; 12 dates with radar and MODIS, 4 dates for radar and MISR and 8 dates for MISR and MODIS and NO radar.
- SGP: 6 cases for MODIS, MISR and radar, 4 extra dates with MISR and radar and 4 other dates for MODIS and radar

Chilbolton: MODIS vs MISR vs 94GHz Radar (1)

MODIS vs MISR vs Radar over Chilbolton (UK)
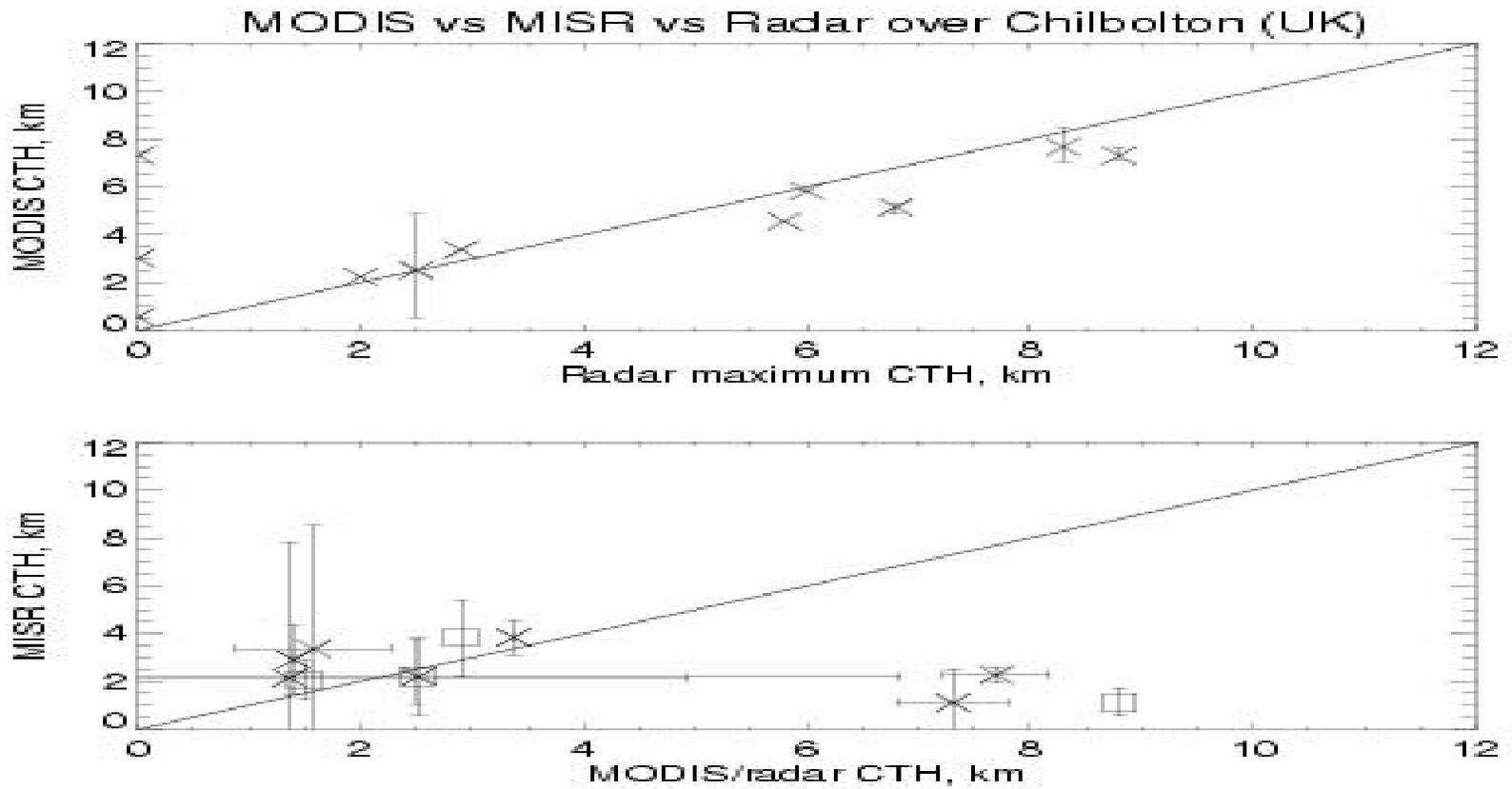
For MISR CTH vs MODIS CTH (X) and MISR vs Radar CTH (❏), MISR misses high clouds around 8km for 2 out of 6 dates: 01-Apr-01 and 17-Apr-01 (MODIS only)

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Chilbolton: MODIS vs MISR vs 94GHz Radar (2)
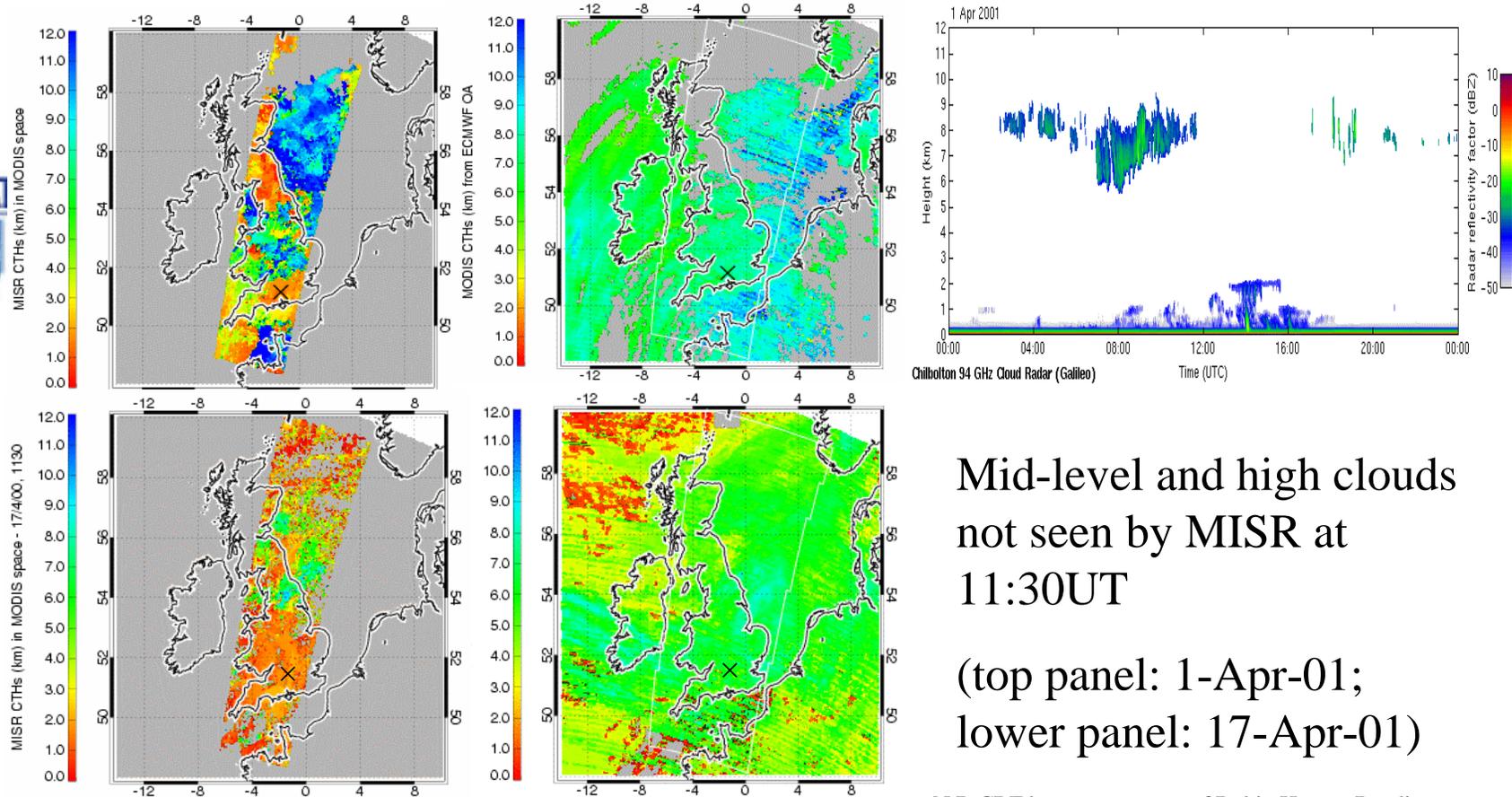
Mid-level and high clouds not seen by MISR at 11:30UT

(top panel: 1-Apr-01; lower panel: 17-Apr-01)

N.B.CRF browse courtesy of Robin Hogan, Reading

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Chilbolton: MODIS vs MISR vs 94GHz Radar (3)

Date	Mean MODIS CTH	Mean MISR CTH	Maximum Radar CTH
25/8/00	7.32		0.00
29/8/00	1.36	2.14	
01/09/00	5.83		6.00
07/09/00		2.05	1.5
21/09/00	3.37	3.84	2.9
24/11/00	1.58	3.36	
01/04/01	7.31	1.11	8.8
13/04/01	2.24		2.00
17/04/01	7.70	2.27	
19/04/01	2.52	2.2	2.5
22/04/01	5.15		6.8
01/05/01	7.67		8.3
03/05/01	1.4	2.91	
31/05/01	3.02		0.00
09/06/01	4.57		5.8

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SGP: MODIS vs MISR vs 35GHz Radar (1)
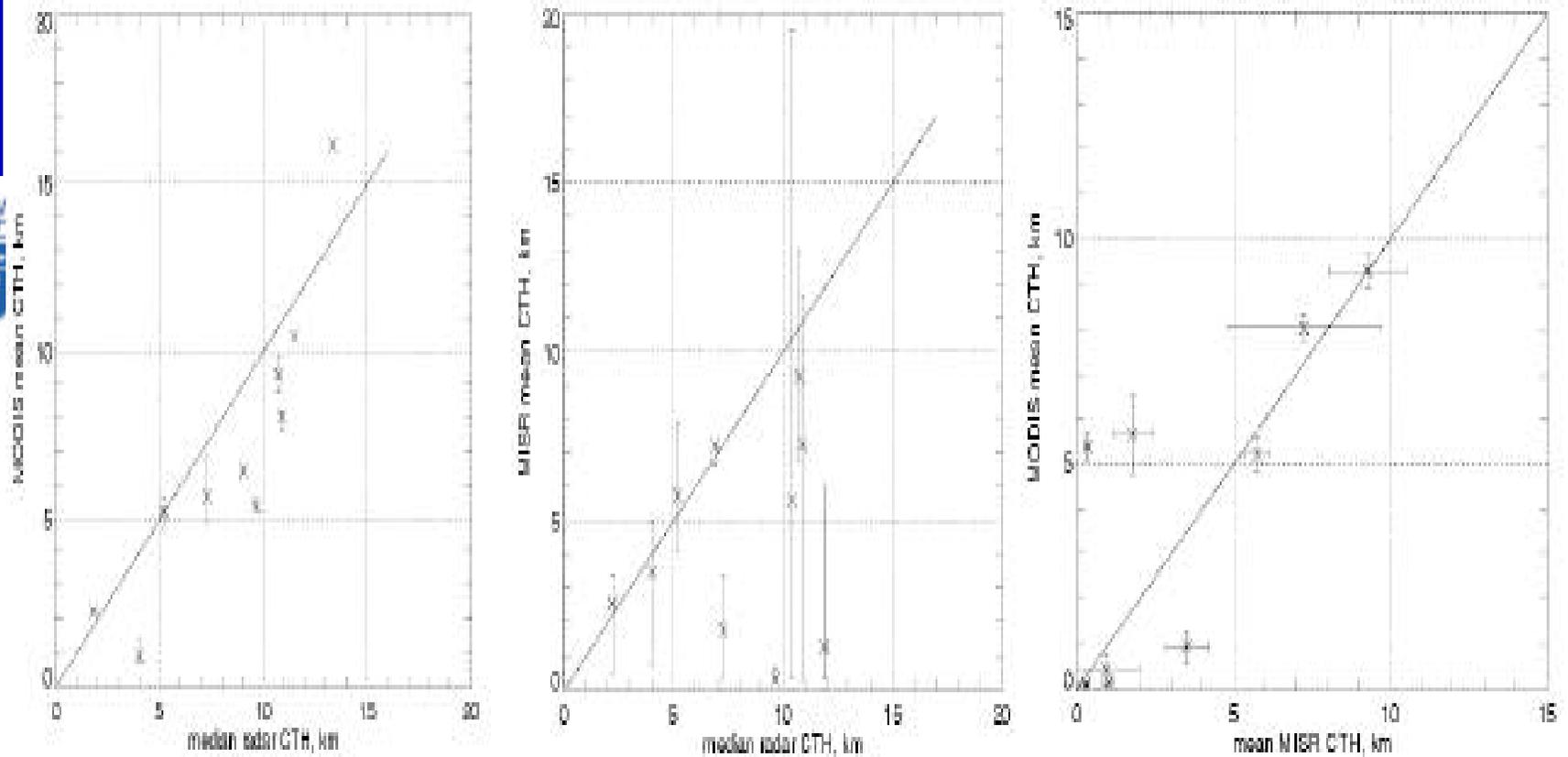
MISR entirely misses high and mid-level clouds for 15-Mar-01, 22-Mar-01 and 22-Aug-01

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SGP: MODIS vs MISR vs 35GHz Radar (2). Note very bad blockiness
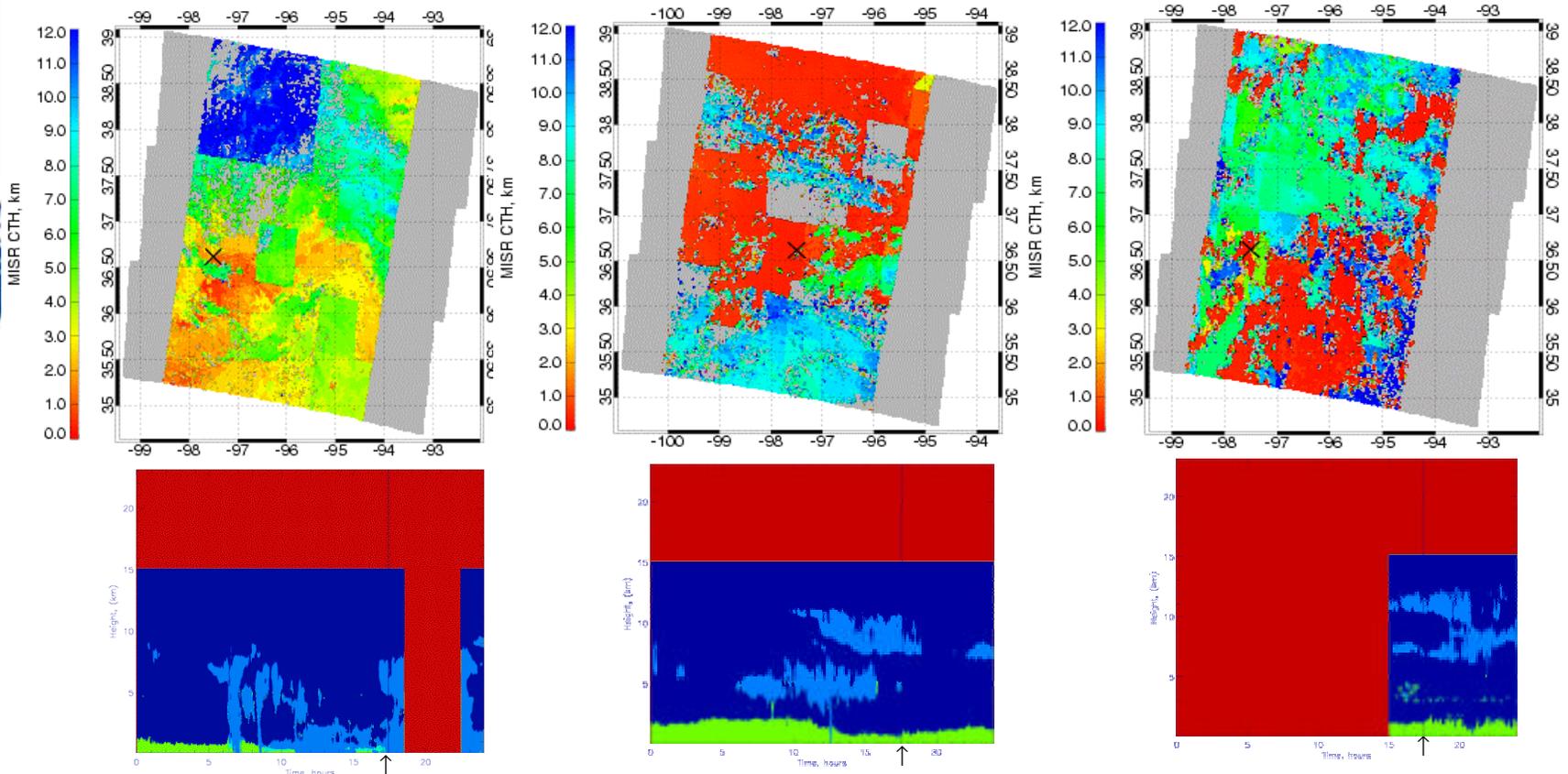
Overpass around 17:00LT, MISR CTH and corresponding radar reflectivity clutter flag for 15-Mar-01, 22-Mar-01, 22-Aug-01- MISR misses high clouds.

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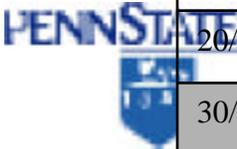
SGP: MODIS vs MISR vs 35GHz Radar (3)

Date	Mean MISR CTH	Mean MODIS CTH	Median 5min radar CTH
06/03/01	7.25	8.04	10.91
15/03/01	1.77	5.68	7.26
22/03/01	0.33	5.39	9.65
10/04/01		10.46	11.49
20/04/01		6.45	9.02
30/04/01	9.28	9.3	10.73
29/05/01		16.18	13.34
31/05/01		2.22	1.82
01/06/01	5.75	5.23	5.19
03/06/01	3.61	0.95	4.02
10/06/01	7.24		6.9
26/06/01	2.55		2.22
05/07/01	5.60		10.41
22/08/01	1.27		11.90

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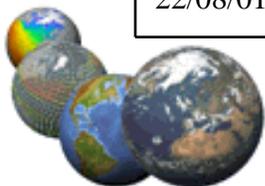
Conclusions

- MISR CTH lower than MODIS CTH for sample of dates examined, but higher for the highest clouds in scene as observed for 23 dates over the British Isles.

- Difficult to identify any correlation between MISR-MODIS CTH differences and MODIS-derived key microphysical parameters (from MOD06 products)

- Comparison with radar data for SGP and Chilbolton:
  - MODIS and MISR slightly underestimate CTH of clouds above 6km cf. Radar
  - MISR misses high clouds in some cases: appears to be related to scenes with multiple cloud levels or mixed and scattered clouds.

- Detailed intercomparison underway with Richard Frey/Paul Menzel (SSEC) to understand differences

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Future work

- Need more cases for validation against ground-based measurements:
  - 2 other ARM sites (NSA and TWP)
  - Radiosonde stations : CARDS database (2500 stations over the entire globe). Will use Chernykh and Eskridge (1996) technique for cloud boundary detection with temperature, dew point and relative humidity profiles
  - require streamlined method for ordering MISR & MODIS for validation
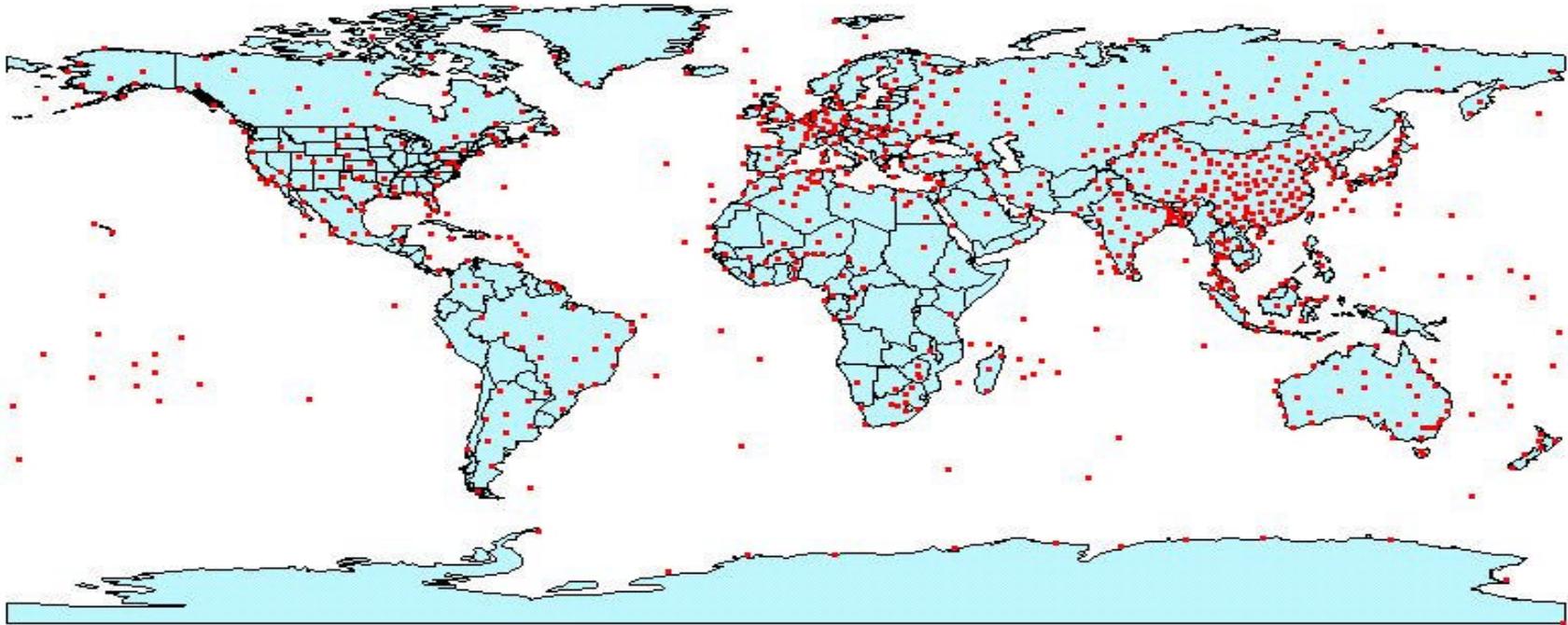
CARDS database: active stations as of May 2000 limited to synoptic times 0 & 12UT
(source: http://lwf.ncdc.noaa.gov/oa/climate/cards/cards_map_act.html)